Appendix A

Forecasting and Conservation Information

for the

City of Marshall

BRIGO Forecast Work Plan
7849.0270 Peak Demand and Annual Consumption Forecast
Subpart 2

Consumers by Customer Class

Historical Consumers - System										
	Farm	Non-farm	Irrigation	Commercial	Industrial	Mining	S&H Lighting	Electric Trans.	Other	Total
1995		5072		785	87		1			5945
1996		5156		788	92		1			6037
1997		5124		798	92		1			6015
1998		5116		813	96		1			6026
1999		5092		857	91		1			6041
2000		5140		855	90		1			6086
2001		5181		848	91		1			6121
2002		5236		860	89		1			6186
2003		5328		870	87		1			6286
2004		5355		889	87		1			6332
Forecast Consumers - System										
	Farm	Non-farm	Irrigation	Commercial	Industrial	Mining	S&H Lighting	Electric Trans.	Other	Total
2005		5434		893	90		1			6418
2006		5472		905	90		1			6468
2007		5510		918	90		1			6519
2008		5548		931	91		1			6571
2009		5587		944	91		1			6623
2010		5626		957	91		1			6675
2011		5665		970	92		1			6728
2012		5704		984	92		1			6781
2013		5744		998	92		1			6835
2014		5784		1012	93		1			6890
2015		5824		1026	93		1			6944
2016		5864		1040	93		1			6998
2017		5905		1055	94		1			7055
2018		5946		1070	94		1			7111
2019		5987		1085	94		1			7167
2020		6029		1100	95		1			7225

Non-farm average increase for 1995 - 2005 is 0.695%
Commercial average increase for 1995 - 2005 is 1.31%
Industrial average increase for 1995 - 2005 is 0.390%

These increases were applied for the years 2006 - 2020

Consumption by Customer Class

Historical Energy (MWh)										
	Farm	Non-farm	Irrigation	Commercial	Industrial	Mining	S&H Lighting	Electric Trans.	Other	Total
1995		50,335.72	-	28,346.73	281,322.23	-	837.13	-	-	360,841.81
1996		51,095.20	-	28,828.11	285,434.84	-	842.55	-	-	366,200.69
1997		50,445.40	-	28,192.56	379,427 12	-	837.57	-	-	458,902.64
1998		49,541.45	-	27,896.06	425,956.45	-	927.97	-	-	504,321.92
1999		48,095.72	-	27,927.88	433,181.41	-	976.95	-	-	510,181.95
2000		50,624.16	-	29,493.94	450,034.57	-	931.58	-	-	531,084.25
2001		54,050.78	-	29,975.62	461,356.67	-	933.39	-	-	546,316.45
2002		55,699.77	-	30,578.02	465,038.87	-	941.36	-	-	552,258.02
2003		56,662.48	-	31,784.15	477,699.17	-	954.47	-	-	567,100.27
2004		55,641.33	-	31,753.04	483,823.23	-	941.36	-	-	572,158.96
Forecast Energy (MWh)										
	Farm	Non-farm	Irrigation	Commercial	Industrial	Mining	S&H Lighting	Electric Trans.	Other	Total
2005		60,286.22	-	34,914.32	495,112.49	-	1,180.61	-	-	591,493.64
2006		61,799.20	-	35,790.55	507,538.14	-	1,210.24	-	-	606,338.14
2007		62,380.11	-	36,126.98	512,308.95	-	1,221.62	-	-	612,037.66
2008		63,031.12	-	36,504.01	517,655.53	-	1,234.37	-	-	618,425.03
2009		63,607.57	-	36,837.85	522,389.68	-	1,245.65	-	-	624,080.75
2010		64,220.43	-	37,192.79	527,422.94	-	1,257.66	-	-	630,093.82
2011		64,925.28	-	37,601.00	533,211.68	-	1,271.46	-	-	637,009.42
2012		65,608.42	-	37,996.63	538,822.07	-	1,284.84	-	-	643,711.96
2013		66,317 16	-	38,407.09	544,642.75	-	1,298.72	-	-	650,665.72
2014		66,985.38	-	38,794.09	550,130.67	-	1,311.80	-	-	657,221.95
2015		67,618.23	-	39,160.60	555,328.05	-	1,324.20	-	-	663,431.07
2016		68,208 11	-	39,502.22	560,172.56	-	1,335.75	-	-	669,218.64
2017		68,786.57	-	39,837.24	564,923.29	-	1,347.08	-	-	674,894.17
2018		69,316.96	-	40,144.40	569,279.16	-	1,357.46	-	-	680,097.99
2019		69,821.58	-	40,436.66	573,423.53	-	1,367.35	-	-	685,049.12
2020		70,379.24	-	40,759.62	578,003.39	-	1,378.27	-	-	690,520.52

2005 is base year
Non Farm is 10.2% of Total KWh
Commercial is 5.9% of Total
Industrial is 83.7% of Total
S&H Lighting is 0.2% of Total

These percentages were applied to MRES Kwh forecast for 2006 - 2020

Peak Demand by Customer Categories

Historical Demand (MW)													
	Farm	Non-farm	Irrigation	Commercial	Industrial	Mining	S&H Lighting	Electric Trans.	Other				Total
1995	0	7.96	-	4.48	44.49	-	0.13	-	-	-	-	-	57.06
1996	0	8.38	-	4.73	46.83	-	0.14	-	-	-	-	-	60.08
1997	0	7.79	-	4.36	58.61	-	0.13	-	-	-	-	-	70.89
1998	0	7.46	-	4.20	64.16	-	0.14	-	-	-	-	-	75.97
1999	0	7.48	-	4.34	67.38	-	0.15	-	-	-	-	-	79.36
2000	0	7.60	-	4.43	67.58	-	0.14	-	-	-	-	-	79.75
2001	0	8.26	-	4.58	70.51	-	0.14	-	-	-	-	-	83.50
2002	0	8.36	-	4.59	69.76	-	0.14	-	-	-	-	-	82.85
2003	0	8.26	-	4.63	69.63	-	0.14	-	-	-	-	-	82.66
2004	0	8.19	-	4.67	71.21	-	0.14	-	-	-	-	-	84.21
Forecast Demand (MW)													
	Farm	Non-farm	Irrigation	Commercial	Industrial	Mining	S&H Lighting	Electric Trans.	Other				Total
2005	0	8.82	-	5.11	72.47	-	0.17	-	-	-	-	-	86.57
2006	0	8.90	-	5.15	73.09	-	0.17	-	-	-	-	-	87.31
2007	0	9.01	-	5.22	73.98	-	0.18	-	-	-	-	-	88.38
2008	0	9.12	-	5.28	74.88	-	0.18	-	-	-	-	-	89.46
2009	0	9.22	-	5.34	75.69	-	0.18	-	-	-	-	-	90.42
2010	0	9.32	-	5.40	76.54	-	0.18	-	-	-	-	-	91.44
2011	0	9.44	-	5.47	77.52	-	0.19	-	-	-	-	-	92.61
2012	0	9.56	-	5.53	78.47	-	0.19	-	-	-	-	-	93.74
2013	0	9.68	-	5.60	79.46	-	0.19	-	-	-	-	-	94.92
2014	0	9.79	-	5.67	80.38	-	0.19	-	-	-	-	-	96.03
2015	0	9.90	-	5.73	81.27	-	0.19	-	-	-	-	-	97.08
2016	0	10.00	-	5.79	82.09	-	0.20	-	-	-	-	-	98.07
2017	0	10.09	-	5.85	82.89	-	0.20	-	-	-	-	-	99.03
2018	0	10.18	-	5.90	83.63	-	0.20	-	-	-	-	-	99.91
2019	0	10.27	-	5.95	84.33	-	0.20	-	-	-	-	-	100.75
2020	0	10.36	-	6.00	85.11	-	0.20	-	-	-	-	-	101.67

2005 is base year
Non Farm is 10.2% of Total KWh
Commercial is 5.9% of Total
Industrial is 83.7% of Total
S&H Lighting is 0.2% of Total

These percentages were applied to MRES Kw forecast for 2006 - 2020

System Peak Demand by Month

	January	February	March	April	May	June	July	August	September	October	November	December
Historical Demand (MW)												
1992	41.61	39.74	38.69	37.35	38.60	45.27	45.26	46.78	47.27	44.04	45.47	46.58
1993	48.63	48.87	47.76	45.40	44.45	47.53	50.05	53.99	53.99	46.50	46.66	48.16
1994	51.47	52.89	48.79	47.21	46.98	53.52	52.02	53.99	53.91	48.16	46.82	50.60
1995	50.56	51.31	50.92	51.31	46.74	54.86	57.06	56.51	55.25	46.82	51.39	54.38
1996	54.07	53.75	52.02	48.95	51.95	60.08	54.72	53.08	49.32	51.08	55.96	56.40
1997	58.76	58.52	61.28	62.14	60.12	68.18	70.88	69.28	70.89	67.80	69.29	70.70
1998	73.35	72.33	68.88	65.52	72.40	73.20	75.64	75.97	74.49	66.41	66.78	70.32
1999	70.97	71.50	67.68	68.88	67.52	75.53	79.36	75.36	75.77	66.81	67.36	70.08
2000	69.44	69.25	66.80	68.88	68.73	75.63	79.25	79.75	71.68	68.43	71.48	74.59
2001	72.75	74.88	70.72	69.22	76.53	81.06	82.39	83.50	78.05	72.31	70.96	69.23
2002	72.17	71.67	71.29	72.00	75.17	81.05	82.85	82.17	81.29	72.44	72.04	72.15
2003	77.91	75.86	73.46	72.06	74.63	82.29	82.58	82.66	77.91	73.21	73.11	75.80
2004	79.89	78.24	73.75	73.23	75.84	81.20	84.21	82.43	80.68	72.86	73.75	79.37
Forecast Demand (MW)												
	January	February	March	April	May	June	July	August	September	October	November	December
2005	79.40	77.50	75.89	74.05	74.73	86.57	85.65	86.31	81.39	74.71	75.60	80.32
2006	78.45	80.75	77.16	76.03	78.94	86.96	87.31	86.90	82.21	77.14	77.19	80.65
2007	82.28	81.07	77.24	76.86	79.82	87.99	88.38	87.95	83.14	77.98	78.05	81.59
2008	83.26	82.02	78.11	77.71	80.72	89.04	89.46	89.03	84.10	78.84	78.93	82.55
2009	84.12	82.86	78.88	78.46	81.52	89.97	90.42	89.98	84.94	79.61	79.71	83.41
2010	85.04	83.76	79.69	79.26	82.37	90.96	91.44	90.99	85.84	80.42	80.54	84.31
2011	86.10	84.78	80.63	80.17	83.34	92.09	92.61	92.16	86.88	81.35	81.50	85.35
2012	87.12	85.78	81.54	81.06	84.28	93.20	93.74	93.29	87.88	82.25	82.42	86.36
2013	88.18	86.81	82.49	81.98	85.26	94.34	94.92	94.46	88.92	83.19	83.38	87.41
2014	89.19	87.79	83.38	82.85	86.19	95.42	96.03	95.56	89.90	84.08	84.28	88.39
2015	90.14	88.71	84.22	83.67	87.06	96.44	97.08	96.60	90.82	84.91	85.14	89.33
2016	91.02	89.57	85.01	84.44	87.88	97.39	98.07	97.58	91.69	85.69	85.94	90.20
2017	91.89	90.41	85.78	85.19	88.67	98.32	99.03	98.53	92.54	86.46	86.72	91.05
2018	92.68	91.19	86.48	85.88	89.41	99.17	99.91	99.41	93.32	87.16	87.44	91.84
2019	93.44	91.92	87.15	86.53	90.10	99.99	100.75	100.24	94.06	87.83	88.12	92.58
2020	94.28	92.73	87.90	87.26	90.87	100.89	101.67	101.16	94.87	88.57	88.88	93.41

2006 - 2020 from MRES Forecast

Average Weekday Load Factor	
January	93.08%
February	92.97%
March	93.70%
April	91.69%
May	92.07%
June	91.16%
July	91.38%
August	91.13%
September	91.06%
October	92.24%
November	93.58%
December	93.20%

Subp. 3

A. Forecasting Process

The following steps were followed to develop a load forecast for Marshall, MN.

Develop a Long-Term Energy Forecast

This included updating the historical files for monthly energy usage and all of the independent variables, forecasting values for independent (explanatory) variables, generating long-term energy models, including spot load adjustments; and selecting a final long-term energy model. The long-term forecast was based on a regression analysis of annual historical data from 1981 through 2003, and created annual energy forecasts through 2030. The resulting long-term model is discussed in more detail below in Section B. Long-Term Load Forecast.

Develop Short-Term Models

Independently of the long-term modeling process, a short-term forecast was generated using a multiple regression analysis. The short-term forecast was based on a regression analysis of monthly historical data from July 2000 through June 2005, and created monthly energy forecasts through June 2007. Details can be found below in Section C. Short-Term Load Forecast.

Blend Short-term and Long-term Forecasts

The short-term forecasts were used for each member through December 2006. After that, Marshall's annual growth rates from the long-term forecast were applied to the short-term forecast. This creates a long-term "blended" forecast that predicts Marshall's demand and energy from July 2005 through December 2030.

B. Long-Term Load Forecast

Purpose

A long-term load forecast was completed for Marshall, MN in December 2005. The purpose of the Long-Term Forecast is to provide an accurate estimate of total energy until the year 2030. This data will be used for estimating long-term capacity needs.

Methodology

Annual data for variables believed to be useful in predicting total energy were input into a software package called MetrixND® and regression models were constructed. The city total energy was the dependent variable for each model. Possible independent variables included county census data for Lyon County in which Marshall is located, weather data from the nearest weather station, national economic statistics, and alternate fuel prices for the region. A number of possible models were tested, and certain criteria were scrutinized in order to find a model that was statistically sound and provided a reasonable expected growth rate. Models were selected primarily based on adjusted R-square, Mean Absolute Percentage Error (MAPE), T-statistics, and Durbin-Watson statistics. The following pages contain more information on each of the potential variables and how each statistic was evaluated. The regression was run using annual energy data starting in 1981.

Correlation between independent variables used in the models was checked with the correlation matrix feature found in MetrixND®. An 85% level was used to identify variables that could be strongly correlated. Models with multicollinearity were revised until the only variables surpassing the 85% level were believed to be coincidentally related.

Implementation

After the models were selected, the resulting forecasted annual load was exported into Microsoft® Excel, where the annual growth rate percents were calculated. These percentages were applied to the results of the short-term monthly demand and energy forecast done for Marshall.

Variables Considered for the Forecast Model

Total Energy (tot_eng and ln_tot_eng)

Historic annual total energy between 1981 and 2003 was used for the dependent variable in the regression model selected. The logarithm of total energy was also examined as a potential dependent variable.

County Census Data (pop, emp, wage, thh, inc, ipc, inc3, ipc3, ln_pop, ln_emp, ln_wage, ln_thh, ln_inc, ln_ipc, ln_inc3, ln_ipc3)

County census data was obtained from the 2004 Woods & Poole State Profile, which included data starting in 1969 and continuing through 2030. Variables obtained from the census include population, employment, wage, total households, income, and income per capita. Income and income per capita had extensive annual fluctuations for some counties, so a 3-year moving average transformation was added for these variables. Logarithmic functions of all variables mentioned above were also considered. 1996 was the base year for all monetary variables above that are indexed. The model selected for Marshall included the logarithm of wages.

Weather Data (cdd, hdd, tdd, ln_cdd, ln_hdd, ln_tdd)

Annual cooling degree-days, heating degree-days, and total degree-days for the years between 1970 and 2003 were collected from the National Oceanic and Atmospheric Administration (NOAA) for the Huron, SD weather station and considered as potential variables. The Huron site was assigned to Marshall. For the years between 2004 and 2020, it was assumed that all degree-day variables would be equal to the last 30-year (1970-2000) normals published by NOAA. Logarithmic functions of all variables mentioned above were also considered. The model selected for Marshall did not include a weather component.

National Economic Data (ipi, gdpd, ln_ipi, ln_gdpd)

National economic statistics were included as potential variables to help estimate long-term growth due to national economic growth. No national economic variable was included in the model selected for Marshall. The industrial production index was a statistic that could be chosen in the regression if the city has a significant industrial component. The industrial production data indexed to 1997 was obtained from Economy.com.

The gross domestic price deflator was a statistic that could be chosen regardless of city size. This statistic is an index that measures the rate of inflation in gross domestic product relative to a base year, so it sufficiently accounts for growth in national economic productivity and should correspond to long-term growth in a city's electricity consumption. Gross domestic price deflator data was obtained from the Bureau of Economic Analysis via Economy.com. The base year used for the GDPD was 2000. Logarithmic functions of all variables mentioned above were also considered.

Alternate Fuel Prices (res_natgas, com_natgas, res_prop, res_oil, com_oil, ln_res_natgas, ln_com_natgas, ln_res_prop, ln_res_oil, ln_com_oil)

Prices of alternate fuels were assumed to be possible significant variables in estimating the city's long-term electricity consumption.

Alternate fuel prices for 1970 through 2002 for natural gas and 1970 through 2000 for heating oil and propane were obtained from the Energy Information

Administration and the Minnesota Department of Commerce. Data was in nominal dollars and later converted to 2000 dollars using the gross domestic price deflator. Data for 2003 through 2025 for natural gas and 2001 through 2025 for heating oil and propane was obtained from the EIA Annual Energy Outlook Table 14 – Energy Prices by Sector and Source for the West North Central region. This data was in 2002 dollars, and later converted to 2000 dollars by using the gross domestic price deflator. In addition, alternate fuel prices were further divided into residential and commercial components. Logarithmic functions of all variables mentioned above were also considered. The model selected for Marshall included the logarithm of residential natural gas as a variable.

Key Statistics

Adjusted R-square: The adjusted R-square represents the percent variation in total annual energy that is explained by the variables used in the model. Unlike standard R-square, adjusted R-square is corrected to remove bias towards models with greater number of variables. Every effort was made to maximize this statistic while keeping other variables at an acceptable level.

Mean Absolute Percent Error (MAPE): MAPE is the average of the absolute values of the percentage residuals. Therefore, models with lower MAPE more accurately account for past fluctuations in total electricity. When selecting models, models with a lower MAPE were chosen over those with a higher MAPE.

Durbin-Watson: The Durbin-Watson statistic tests for the presence of residual correlation. The range for Durbin-Watson is between 0 and 4. Values of 2 signify residuals are uncorrelated, meaning successive residuals in the time series are random rather than related. If the residuals are positively correlated, the value will be less than 2, and stronger correlation is implied as the number approaches 0. If the residuals are negatively correlated, the value of the Durbin-Watson statistic will be greater than 2, and stronger negative correlation is implied as the value approaches 4. The Durbin-Watson statistic was monitored during model selection, in order that using two variables with strong correlation could be avoided when possible.

T-Statistics: The T-Statistic tests the statistical significance of each corresponding variable in predicting the variation in the dependent variable. Based upon the number of historical observations used in the regression, if the T-Statistic is greater than 2, it is at least 95% certain that the independent variable contributes to the explanation of the dependent variable. If the T-Statistic is equal to 1, it is 66% likely that the independent variable contributes to the explanation of the dependent variable. Generally, the T-Statistic had to be above 1.3 for it to remain in the model as a significant variable that positively impacted the model results.

Model Selection and Statistical Output

On the following pages are the statistical model selected for Marshall and the graphs associated with the model.

The statistical page begins with a section in bold print giving an overview of the model. The Dependent Variable for Marshall is total energy. Estimation Begin Date is the beginning date for the historical data used in the forecast. Estimation End Date is the last year of historical data used in the forecast. Forecast Period End Date is the last year of forecasted data. All data used represents a complete year.

The next section contains data about the variables that were chosen for each model.

The standard error is an estimate of how much the coefficient could vary. Coefficients that are much larger than their standard error terms are more "significant," meaning there is a better probability that it is a good estimate of the actual relationship between the independent variable and the dependent variable, energy sales. Conversely, if the standard error is large compared to the coefficient, there may be a high probability that the true coefficient is zero and this variable is not significant.

The T-statistic is the coefficient divided by the standard error. It is used to test the statistical significance of the variable in explaining the variation of the dependent variable. The independent variables used were chosen primarily based on the T-stat. The higher the T-stat, the more likely that particular variable is useful as a predictor of the dependent variable.

P-Value is another determinant of a variable's usefulness in predicting the dependent variable. The lower the P-Value the more likely that particular variable is useful as a predictor of the dependent variable.

The next section entitled Regression Statistics contains information on the statistics used to evaluate each model. Following are the statistics that were primarily evaluated for each model.

The R-squared measures how much of the variation in the dependent variable can be "explained" in the model. R-squared values lie between 0 and 1, with 1 indicating a perfect fit.

The Adjusted R-squared corrects the R-squared value for the number of degrees of freedom (the number of observations used to calculate a particular statistic less the number of variables included in the equation). R-squared increases with each additional independent variable in the equation, whereas Adjusted R-squared may increase or decrease depending on the overall contribution of the additional variable.

The Durbin-Watson is a test for the randomness of the errors of the equation. In a good model, the errors are randomly distributed and are approximately the same magnitude. Generally, a Durbin-Watson in the range of 1.5 to 2.5 indicates the residuals are random. The "critical value," in determining whether the residuals are non-random depends on the number of variables and observations in the model.

The F-statistic is a statistical test of the overall fit of the estimated equation. The overall fit of the equation is determined to be statistically acceptable when the F-statistic is larger than another "critical value", which again depends on the number of variables and observations in the model.

Mean Absolute Percent Error (MAPE) is the average of the absolute values of the percentage residuals. Therefore, models with lower MAPE more accurately account for past fluctuations in total electricity.

Graphs of Annual Energy and Annual Growth Rates

A graph showing total energy usage in kWh for the years 1981 through 2020 was prepared for Marshall. The amounts shown in the graph for 1981 through 2003 are historical loads and the amounts shown from 2004 through 2020 are forecasted loads for the community. A graph showing percentage growth rates for energy usage for the same time duration was also prepared. The growth rates shown on it include both the annual growth rate as well as the 5-year moving average growth rate. These graphs are located on a page immediately after the statistical output page.

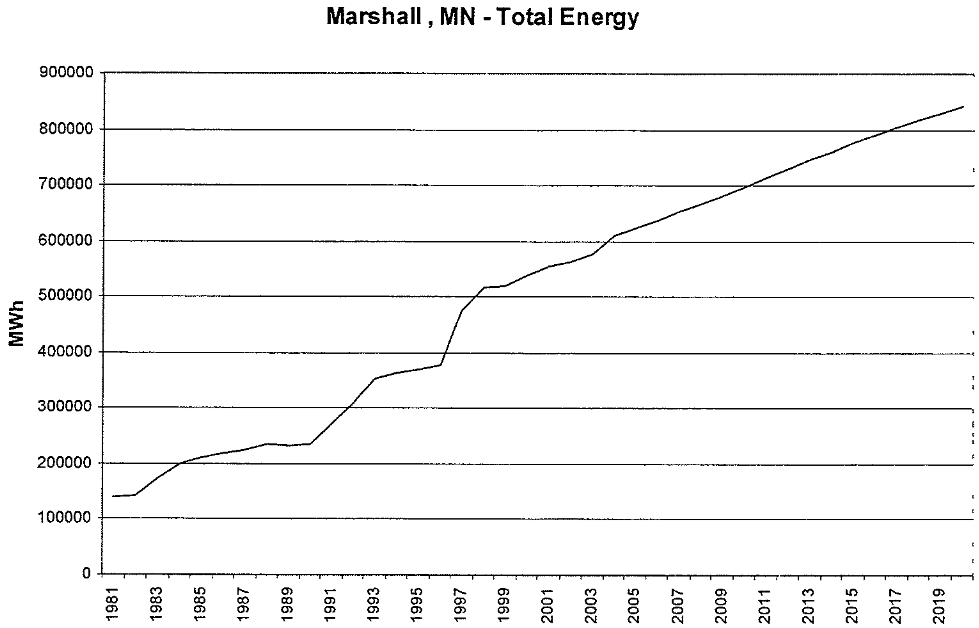
Project:	B:\Brian\LT Forecasting\data_files\LTFC_2004_master_revised9(notrend).NDM
Model:	Marshall MN
Dependent Variable:	tot_eng63
Estimation Begin Date:	1981:1
Estimation End Date:	2003:1
Forecast Period End Date:	2029:1

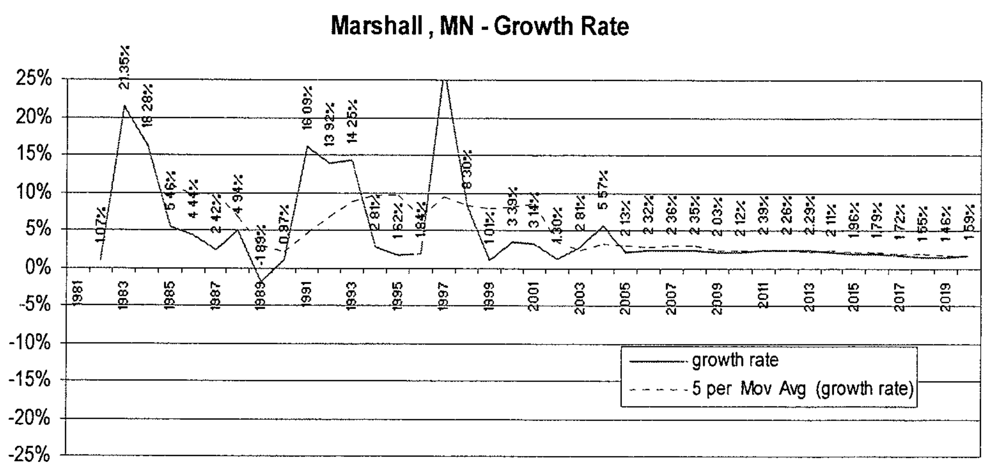
Variable	Coefficient	StdErr	T-Stat	P-Value
CONST	-3544455800 644	183053089 135	-19.363	0%
alt_fuel ln_res_natgas	196966794 136	74956133.416	2 628	2%
county52 ln_wage	1517052528 720	58469309 622	25.946	0%

Regression Statistics	
Iterations	1
Adjusted Observations	23
Deg of Freedom for Error	20
R-Squared	0 976
Adjusted R-Squared	0 973
Durbin-Watson Statistic	1.490
Durbin-H Statistic	#NA
AIC	34.144
BIC	34 293
F-Statistic	398 977
Prob (F-Statistic)	0.0000
Log-Likelihood	-403 94
Model Sum of Squares	476564615708966000
Sum of Squared Errors	11944668012686600
Mean Squared Error	597233400634331 00
Std. Error of Regression	24438359 21
Mean Abs. Dev (MAD)	17366259 42
Mean Abs. % Err (MAPE)	6 01%
Ljung-Box Statistic	3.26
Prob (Ljung-Box)	0 6598

Forecast Statistics	
Forecast Observations	0
Mean Abs Dev (MAD)	0 00
Mean Abs. % Err (MAPE)	0 00%
Avg Forecast Error	0 00
Mean % Error	0 00%
Root Mean-Square Error	0.000
Theil's Inequality Coefficient	0.0000
-- Bias Proportion	0 00%
-- Variance Proportion	0.00%
-- Covariance Proportion	0 00%

Variable	Coefficient	Mean	Elast
ln_res_natgas	196966794 136	0 859	0 499
ln_wage	1517052528.720	2 448	10 950


Marshall, MN - Total Energy
MWh
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019


Marshall, MN - Growth Rate
25%
20%
15%
10%
5%
0%
-5%
-10%
-15%
-20%
-25%
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019
growth rate
5 per Mov Avg (growth rate)

C. *Short-Term Load Forecast*

Purpose

A Short-Term Forecast was completed for Marshall, MN in August 2005. The purpose of the Short-Term Forecast is to provide an accurate estimate of monthly demand and energy. The forecast takes weather and monthly load patterns into account and is blended with the long-term forecast to account for long-term economic factors.

Variables Considered for the Forecast Model

Total Energy (energy, ln_eng)

The logarithm of monthly total town gate energy for Marshall between July 2000 and June 2005 was used for the dependent variable in the regression model. Models using the logarithm of total energy as the dependent variable were also considered.

Weather Variables (cdd, hdd, tdd, ln_cdd, ln_hdd, ln_tdd)

Historic monthly degree-day variables and the logarithmic transformations of these variables between July 2000 and June 2005 were tabulated for the National Oceanographic and Atmospheric Administration (NOAA) Huron, SD weather station. The Huron station was assigned to Marshall for the forecast. All degree-day variables are equal to the 1970-2000 normals as published by NOAA. At least one of the above weather variables was forced into each model considered. Additionally, no more than two weather variables could be included per model. The model selected for Marshall included cooling degree days and heating degree days as variables.

Lagged Energy Variables (lageng1, lageng12, ln_lageng1, ln_lageng12)

Both one-month and twelve-month lagged energy variables were examined as potential variables in the regression model. The model selected did not contain a lagged-energy variable. If the model uses one of these variables, it would suggest that future energy is a function of either one-month or twelve-months prior energy. The logarithmic transformations of one-month and twelve-month lags were also included. Note that only one lag variable or transformation thereof could be included per model.

Trend Variables (trend, ln_trend)

A linear trend variable and the non-linear logarithmic transformation of the linear trend were included as potential variables in the regression model. Any long-term growth (or negative growth) realized by the city should be accounted for by including a trend component. Again, only one trend variable or transformation could be included per model. Trend was used as a variable in the model selected.

Monthly Dummy Variables (d1, d2, d3, d4, d5, d6, d7, d8, d9, d10, d11)

Monthly dummy variables were used to account for the monthly variation in energy sales. Dummy variables take the value of one or zero depending upon a condition occurring or not occurring. There were 11 dummy variables, with the first dummy variable, d1, being equal to 1 for January, and the other 10 dummy variables being equal to 0 in January. The second dummy variable, d2, being equal to 1 for February, and the other 10 dummy variables being equal to 0 for February, and so on. It is mandatory in regression modeling that one month does not have a dummy variable, in order that some base level is set, and subsequent months are either an addition or a subtraction to that base level. In this case December was the month not represented by a dummy variable. All eleven monthly dummy variables were forced into each regression model.

Model Selection

With all variables input into a Microsoft® Excel spreadsheet, over 800 unique models containing all combinations of the above variables were constructed in Excel. Models were sorted based on R-square statistics, Durbin-Watson statistics, T-statistics, and growth rates. This enabled the selection of a model that was statistically sound yet provided a reasonable expected growth rate.

Key Statistics

Adjusted R-square: The adjusted R-square represents the percent variation in total monthly energy that is explained by the variables used in the model. Unlike standard R-square, adjusted R-square is corrected to remove bias towards models with greater number of variables. Every effort was made to maximize this statistic while keep other variables at an acceptable level.

Durbin-Watson: The Durbin-Watson statistic tests for the presence of residual correlation. The range for Durbin-Watson is between 0 and 4. Values of 2 signify residuals are uncorrelated, meaning successive residuals in the time series are random rather than related. If the residuals are positively correlated, the value will be less than 2, and stronger correlation is implied as the number approaches 0. If the residuals are negatively correlated, the value of the Durbin-Watson statistic will be greater than 2, and stronger negative correlation is implied as the value approaches 4. The Durbin-Watson statistic was monitored during model selection, in order that using two variables with strong correlation could be avoided when possible.

T-Statistics: The T-Statistic tests the statistical significance of each corresponding variable in predicting the variation in the dependent variable. Based upon the number of historical observations used in the regression, if the T-Statistic is greater than 2.0, it is at least 95% certain that the independent variable contributes to the explanation of the dependent variable. If the T-Statistic is equal to 1, it is 66% likely that the independent variable contributes to the explanation of the dependent variable. Generally, the T-Statistic had to be above 2.0 for it to remain in the model as a significant variable that positively impacted the model results. Additionally, the coefficients of all variables had to have a positive sign, with the exception of trend or lag variables, for which a negative T-Stat would be appropriate if the city is experiencing negative growth. In this case, the T-Stat is preferred to be greater than 2.0 in absolute value. Note that the T-Statistics of the monthly dummy variables were not considered and the values did not have to be above a certain level.

Spot Loads

ADM accounts for roughly half of Marshall's load. ADM's load is not expected to grow in the future. ADM was subtracted from the history and the forecast was done without ADM. ADM load was added after the regression, and alternate weather and alternate economic forecast bandwidths were applied to the total load without ADM, as ADM is not weather sensitive, and not prone to changes in usage due to economic changes.

Demand Forecasting

A separate demand forecast is not conducted. The demand is a considered to be a function of energy, with monthly 5-year average load factors applied to the expected monthly energy values. The result is monthly estimated demand with a load factor that is equal to the average load factor of the last five years for that particular month.

Weather and Economic Bandwidths

Monthly cooling degree days, heating degree days, total degree days, and the logarithmic functions of these variables were analyzed between 1970 and 2000.

These variables were individually sorted and the mildest 10% of all occurrences were removed from further consideration for the extreme forecast. The most extreme 10% of all occurrences were removed from further consideration for the mild forecast. The highest and lowest remaining degree-day values were saved and later used to replace the 30-year normal degree-day values in the regression models while using coefficients from the original model. The result was both a mild and extreme monthly percentage variance from normal. These monthly percentages were applied to the monthly base demand and energy forecasts as described above. The adjustments to the base forecast represents the mildest and most extreme demand and energy that could be expected 9 out of 10 years. Since weather effects can affect demand and energy immediately, mild and extreme percentage variances were applied beginning the first month of the forecast.

Economic bandwidths were also created. The low and high economic cases assumed a -.5% and a +.5% adjustment to the base demand and energy forecasts respectively. The percentage adjustments are cumulative, and as such, the total adjustment is greater in the year 2017 than in the year 2007. This accounts for the greater level of economic uncertainty further in the future. Since fluctuations in economic health do not affect near-term demand and energy loads, these adjustments first begin in December 2006.

In addition to the mild weather, extreme weather, low economic growth, and high economic growth forecasts, two combination forecasts were also created: the extreme low forecast, and the extreme high forecasts. The extreme low is the same -.5% low economic growth adjustment applied to the extreme weather demand and energy forecasts rather than the base demand and energy forecasts. The extreme high forecast is the +.5% high economic growth adjustment applied to the extreme weather forecast instead of the base demand and energy forecasts. These two forecasts represent the lowest and highest demand and energy loads that could be expected under a combination of extreme weather and low economic growth, and extreme weather and high economic growth respectively.

Implementation

After the model was selected, the resulting forecasted monthly loads were blended with annual growth rates starting in December 2006 (long-term growth rates were calculated in the most recent long-term forecast model for Marshall in December 2005). This step creates a single integrated forecast that includes both short-term and long-term estimates for demand and energy, and is useful for both short-term budgeting as well as long-term planning.

Graphs and Statistics from the Selected Regression Model

A graph showing historical and forecasted monthly energy usage follows. The period from July 2000 to June 2005 represents historical data and the period from July 2005 to June 2007 represents forecasted data.

A graph showing historical and forecasted monthly demand was also prepared for the same time period. The forecast portion of the demand graph was based on the five-year load factor as explained earlier.

Below the graphs are sections pertaining to the statistical measures of the model selected. The section entitled Regression Statistics contains information on the statistics used to evaluate each model. Following are the statistics that were primarily evaluated for each model.

The R-squared measures how much of the variation in the dependent variable can be "explained" in the model. R-squared values lie between 0 and 1, with 1 indicating a perfect fit.

The Adjusted R-squared corrects the R-squared value for the number of degrees of freedom (the number of observations used to calculate a particular statistic less the number of variables included in the equation). R-squared increases with each additional independent variable in the equation, whereas Adjusted R-squared may increase or decrease depending on the overall contribution of the additional variable.

The number of observations was 60 months of historical data for each model.

The Durbin-Watson is a test for the randomness of the errors of the equation. In a good model, the errors are randomly distributed and are approximately the same magnitude. Generally, a Durbin-Watson in the range of 1.5 to 2.5 indicates the residuals are random. The "critical value," in determining whether the residuals are non-random depends on the number of variables and observations in the model.

The Pre-Shift Growth Rate represents the growth between the last year of historical data and the first year of forecast data. The Forecasted Growth Rate represents the growth between the first and second year of forecasted data. The Last 5 Yrs Growth Rate represents the growth between the first year and the fifth year of historical data.

The first section on the bottom contains data about the variables that were chosen for the model. No evaluations of the intercept or the dummy variables were done. Only those variables listed below the dummy variables were evaluated

The standard error is an estimate of how much the coefficient could vary. Coefficients that are much larger than their standard error terms are more "significant," meaning there is a better probability that it is a good estimate of the actual relationship between the independent variable and the dependent variable, energy sales. Conversely, if the standard error is large compared to the coefficient, there may be a high probability that the true coefficient is zero and this variable is not significant.

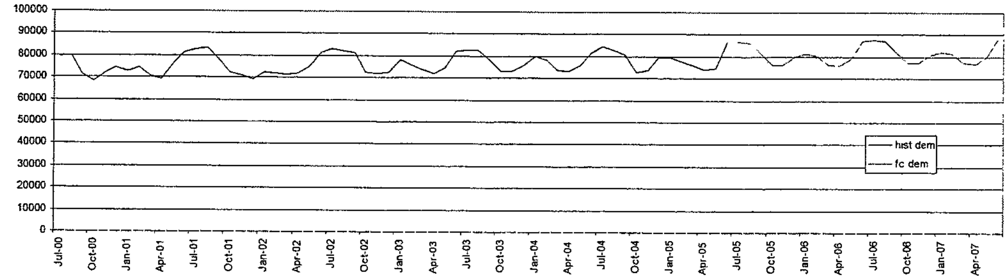
The t-statistic is the coefficient divided by the standard error. It is used to test the statistical significance of the variable in explaining the variation of the dependent variable. The independent variables used were chosen primarily based on the T-stat. The higher the T-stat, the more likely that particular variable is useful as a predictor of the dependent variable.

P-Value is another determinant of a variable's usefulness in predicting the dependent variable. The lower the P-Value the more likely that particular variable is useful as a predictor of the dependent variable.

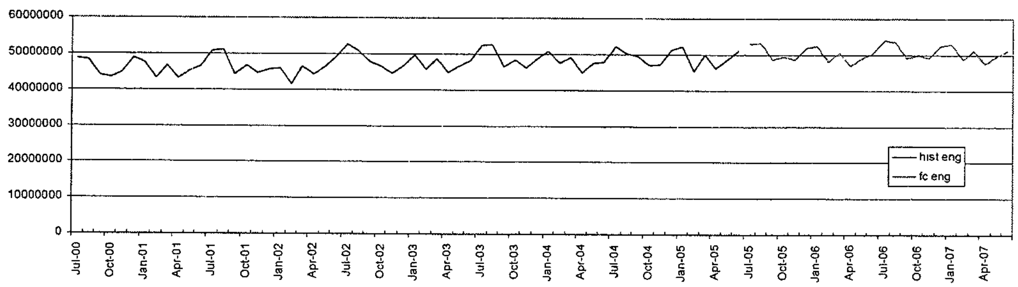
The Lower 95% and Upper 95% columns give the range in which it is at least 95% certain the true coefficient lies.

The section entitled Notes contains information about any adjustments made outside of the normal forecasting procedure.

Marshall, MN Demand Model 63/327



Marshall, MN Energy Model 63/327



Regression Statistics	
Multiple R	0 952
R Square	0 906
Adjusted R Square	0 877
Standard Error	571062 403
Observations	60

Dependent Variable	**energy**				
	df	*SS*	*MS*	*F*	*Significance F*
Regression	14	1 4227E+14	1 0162E+13	31 16177938	1 68355E-18
Residual	45	1 4675E+13	3 2611E+11	0	0
Total	59	1 5695E+14	0	0	0

Durbin Watson	*1 25*
Pre-Shift Growth Rate	2 0%
Forecasted Growth Rate	2 1%
Last 5 Yrs Growth Rate	1 5%

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	16588411 5	846572 7885	19 59	0 00	14883326 4	18293496 6
d1	482392 2016	367828 0756	1 31	0 20	-258451 561	1223235 96
d2	-1180057 88	364757 9498	-3 24	0 00	-1914718 09	-445397 67
d3	178036 6438	390133 9448	0 46	0 65	-607733 445	963806 733
d4	-680343 5619	580303 5545	-1 17	0 25	-1849134 9	488447 777
d5	127594 7229	711046 1958	0 18	0 86	-1304525 81	1559715 25
d6	705193 7564	828780 1526	0 85	0 40	-964055 133	2374442 65
d7	872167 0712	1011827 296	0 86	0 39	-1165757 68	2910091 83
d8	1253351 6	913345 7747	1 37	0 18	-586221 193	3092924 39
d9	-83310 09556	769918 3123	-0 11	0 91	-1634005 15	1467384 96
d10	210616 8454	590238 8917	0 36	0 72	-978185 289	1399418 98
d11	-895643 8604	421829 2998	-2 12	0 04	-1745251 67	-46036 051
trend	37544 22897	4641 459688	8 09	0 00	28195 8494	46892 6085
cdd	13423 72153	2038 213246	6 59	0 00	9318 54938	17528 8937
hdd	2878 277892	563 710198	5 11	0 00	1742 90729	4013 6485

Notes
ADM load not expected to grow in the future ADM was subtracted from the history and city was forecasted without ADM ADM load was added after regression, and alternate weather and alternate economic forecast bandwidth were applied to the total load without ADM as ADM is not weather sensitive and not prone to changes in usage due to economic changes Because the regression was run on Marshall's load without ADM the statistics on this page are based on that The energy and demand graphs however represent Marshall's total load

Subp. 5 Assumptions and special information

A. The availability of alternate sources of energy;

The assumed availability of alternate sources of energy was not an essential assumption in MMU's load forecast.

B. The expected conversion from other fuels to electricity or vice versa;

There is no expected conversion from various fuels to electricity, or vice versa.

C. Future prices of electricity for customers in the applicant's system and the effect that such price changes will likely have on the applicant's system demand;

Historic retail pricing is expected to be stable into the future. MMU has firm contracts with WAPA and MRES for the purchase capacity and energy well into the future. These contracts cover the full requirements of MMU, which greatly limits MMU's exposure to volatile market electricity prices.

D. The data requested in subpart 2 that is not available historically or not generated by the applicant in preparing its own internal forecast;

No such data exists.

E. The effect of energy conservation programs on long-term electrical demand;

MMU has a strong conservation program, and will continue to comply with Minnesota's Conservation Improvement Program (CIP), which requires that utilities spend a portion of their operating revenues on measurable conservation programs. It is assumed that similar measures will be pursued into the future, and therefore, similar demand and energy savings are implicit in MMU's load forecast.

F. Any other factor considered by the applicant in preparing the forecast;

No other relevant factors were considered.

Subpart 6 Coordination of Forecasts with other systems

A. a description of the extent to which the applicant coordinates its load with those of other systems, such as neighboring systems and associate systems in a power pool or coordinating organization; and

MMU is required to submit their forecast to Xcel Energy to be used in Xcel Energy Control Area forecast. The forecast is submitted to Xcel Energy annually. MMU forecast is also included in MRES' total load annual forecast submitted to MAPP for the load and capability report.

B. a description of the manner in which such forecasts are coordinated, and any problems experienced in efforts to coordinate load forecasts.

7849.280 System Capacity (Exemption Requested)

7849.029 CONSERVATION PROGRAMS

A. Mark Antony
Energy Services Coordinator
Marshall Municipal Utilities
113 South 4th Street
Marshall, MN 56258

B. MMU's goal is to promote energy conservation by providing cost effective programs to our customers and assistance in making wise energy decisions. By providing financial incentives to promote energy conservation and demand reduction, MMU can lower our energy costs for our customers and help preserve our energy resources. Programs must also meet Minnesota Department of Commerce CIP conservation spending requirements.

C. Marshall Municipal Utilities (MMU) has considered offering a Variable Speed Drive Incentive Program, a Low Income Energy Efficiency Program, and a Premium Efficiency Motor Program. Current conservation programs offered include: Commercial High Efficiency lighting, Residential lighting, ENERGY STAR® appliance, ENERGY STAR® central air conditioner and heat pump, and a Commercial and Industrial Custom program. Some of the considered programs have not yet been implemented due to MMU making a considerable investment in energy conservation measures for the new YMCA and Marshall Public School over the past few years. Some of these programs will be implemented in the future.

D. MMU has invested over $1.8 million in energy conservation and demand saving measures over the last 5 years in our community. Residential, Commercial, and Industrial customers have all benefited from our programs as well as public facilities such as the Marshall Area YMCA and Public schools.

E. MMU will continue to promote energy conservation through our existing programs and by the implementation of new cost effective programs based on sound business decisions and MN Department of Commerce CIP spending requirements.

F. Current demand and conservation programs are included in our forecasting and will remain in effect. Future demand and conservation spending will help offset our growing need for additional energy. Marshall Municipal Utilities is committed to spend about $200,000 per year on demand and conservation measures, with a minimum of 50% of that amount spent on conservation. Marshall Municipal Utilities consistently meets the CIP spending goals, as established by the State of Minnesota. As our gross operating revenue continues to increase, our conservation spending requirement will also increase.